Status Report

2003-2004 Vegetation Community Monitoring in Fire Management Unit N-1

Effigy Mounds National Monument

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1.0 EXECUTIVE SUMMARY

Over the past decade, prescribed fire has been employed at Effigy Mounds National Monument (EFMO) at a small scale, focusing on maintaining remnant goat prairies and restored tallgrass prairies. More recently, park managers have realized the need for large-scale prescribed fire in the heavily forested areas surrounding the mounds. Park managers recognize the cultural landscape of the mounds as open, savanna-like woodlands and the important role of fire in restoring and maintaining the landscape. There is concern that forest succession as a result of fire suppression at EFMO is resulting in a loss of forest diversity and degradation of park mandated viewscapes.

Regeneration and overstory data suggest a transition is occurring from a drier, oak/hickory forest to one dominated by more mesic species, particularly sugar maple. Using tree core analysis, Grabner *et al.* (2000) determined that the invasion of sugar maple, basswood and additional mesic species has occurred within the last 40 years. This succession favors climax forests, at the loss of prairie and savanna communities, as nearly 1,200 acres of the monument are rapidly becoming mature stands of mixed hardwood species.

Starting in 1997, with the implementation of 11 permanent sites in grassland areas, the Heartland I&M Network and Prairie Cluster Prototype Monitoring Program (HTLN) has been monitoring plant communities at EFMO. In response to the expanded Fire Management Plan (NPS 2003), fire effects monitoring in the forested areas of EFMO was initiated through a joint effort of the HTLN and the Mid-West Region Fire Effects Monitoring Program. Initially sample sites were installed and measured in FMU N-1 in 2003 and 2004. Additionally, thirteen new sample sites were located in N-2, N-3, S-1 and S-2 during early spring 2005 to be used for the baseline monitoring during the following growing season. There are currently 18 long-term plant community monitoring sites in the woodlands at EFMO in five FMU's. This report focuses on the two consecutive years of data collected in FMU N-1 in the 2003-2004 seasons.

For two phases of the Midwestern White Oak – Red Oak Forest type, sugar maple seedlings were successfully reduced following a spring 2004 burn. In the oak – hickory phase (FOH) of the forest community, sugar maple regeneration was reduced dramatically after the fire with total seedlings in the four sites declining from 1569 in 2003 to 50 in 2004 (3922.5 per hectare and 125 per hectare, respectively). Sugar maple regeneration in the single site in the white oak – chinquapin forest phase (FWO) was also greatly reduced from 1642 stems in 2003 to 256 in 2004 (16420/ha and 2560/ha). After only one fire, there has not been a response in the oak component, with negligible oak regeneration both before and after the fire.

In the oak – hickory forest phase, exotic species were not greatly affected, with the only change being the addition of the common dandelion to the sites. Garlic mustard, which occurred prior to the fire, did not change in frequency or foliar cover after the fire. Unfortunately, in the white oak – chinquapin forest phase both garlic mustard and multiflora rose were new additions after the fire. However, with only one sample site in this forest community the effect cannot be directly attributed to the prescribed fire.

The data from the additional FMU's collected in the next few years will add to the knowledge gained from the FMU burned in 2004 and allow for greater interpretation of the results. The additional baseline monitoring in the EFMO woodlands will help park staff to predict the possible impacts of management decisions on forested ecosystems.

2.0 INTRODUCTION

2.1 Background

Over the past decade, prescribed fire has been employed at Effigy Mounds National Monument (EFMO) at a small scale, focusing on maintaining remnant goat prairies and restored tallgrass prairie areas (Figure 1). In 1997, plant community monitoring of these grassland sites was initiated by the Prairie Cluster Prototype Long-term Ecological Monitoring Program, now the Heartland I&M Network and Prairie Cluster Prototype Monitoring Program (HTLN). To date, 11 permanent sites have been deployed and periodically monitored in the grassland portions of EFMO.

Park managers now recognize the cultural landscape of the mounds as open, savanna-like woodlands and the important role of fire in restoring and maintaining the landscape. Additionally, there is concern that forest succession is resulting in a loss of forest diversity and degradation of park mandated viewscapes. Early survey records reveal that northeastern Iowa was a heavily forested region interspersed with oak savannas and prairie openings. This continuum consisted of prairie openings penetrating into the forest area along ridge tops with smaller prairie openings found on south facing bluff edges. Today as a result of fire suppression, the steep hillsides are dominated by climax stands of maple-basswood and oak-hickory communities with small goat prairies found on drier sites.

The revised Fire Management Plan (NPS 2003) calls for landscape scale prescribed fire, dividing the monument into 16 fire management units (FMUs) to implement future prescribed fire (Figure 2). In response to the expanded Fire Management Plan, fire effects monitoring in the forested areas of EFMO was initiated through a joint effort of the HTLN and the Mid-West Region Fire Effects Monitoring Program.

Field work in 2003 focused on establishing fire effects monitoring sites in the first woodland unit scheduled to burn in spring 2004 (FMU N-1). Ideally, all sites would be deployed simultaneously, but time and personnel constraints limited the initial deployment to five sample sites in unit N-1. Sample sites were installed and measured in FMU N-1 pre-burn on July 8-10, 2003 and post-burn on July 20, 2004. Field efforts for the 2005 field season focused on the North and South Fire Management Units. Heartland Network staff established thirteen new sample sites located in N-2, N-3, S-1 and S-2 during early spring 2005 to be used for the baseline monitoring during the following growing season. There are currently 18 long-term plant community monitoring sites in the woodlands at EFMO in five FMU's (Figure 3). This report will focus on the two consecutive years of data collected in FMU N-1 in the 2003-2004 seasons.

2.2 Objectives

Plant community monitoring at EFMO is designed to detect and describe changes in prairie and woodland communities. There are four primary objectives for the monitoring:

1. Describe the plant species composition, structure, and diversity of prairie and woodland communities;

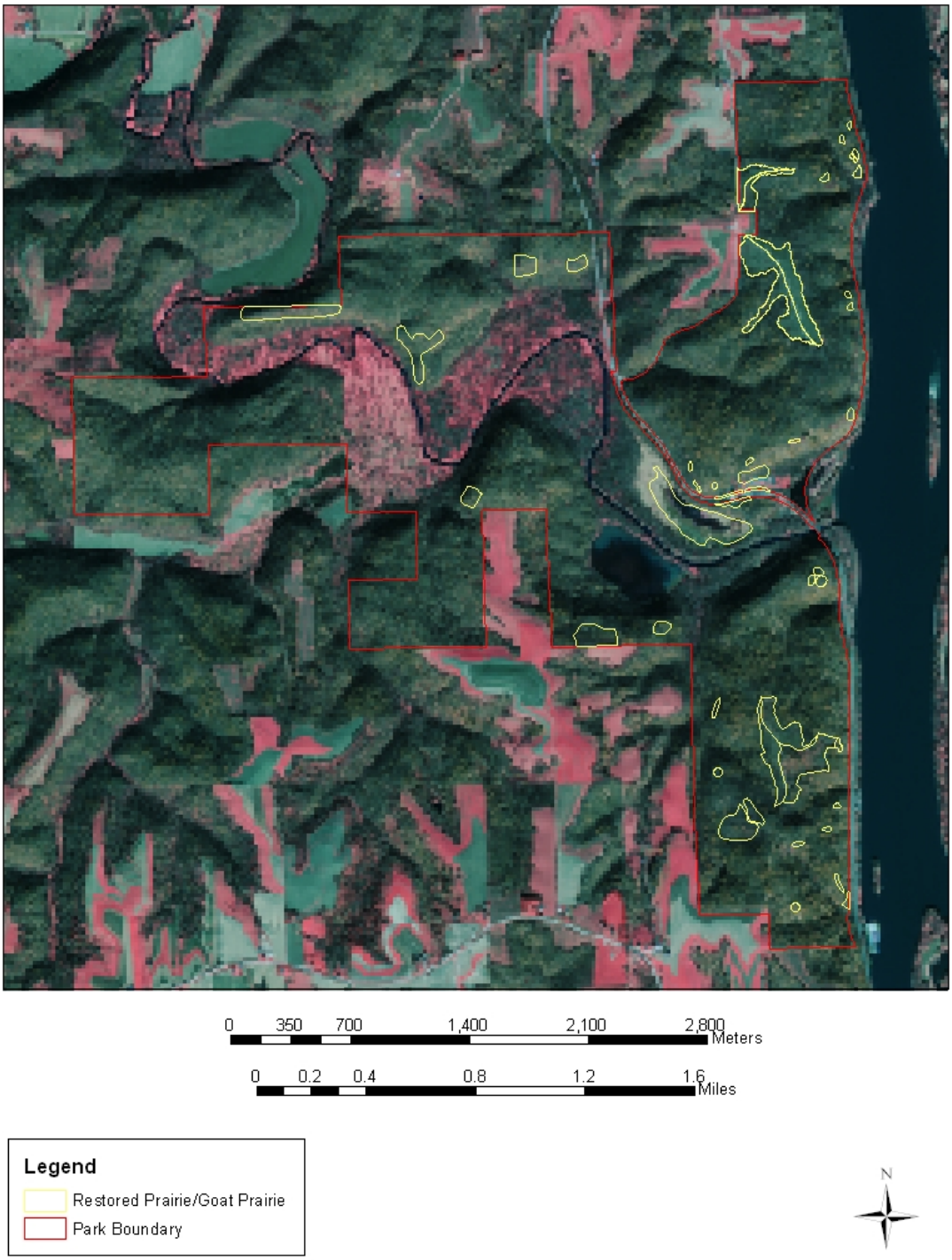

Figure 1 Goat prairie and tallgrass prairie management units at Effigy Mounds National Monument.

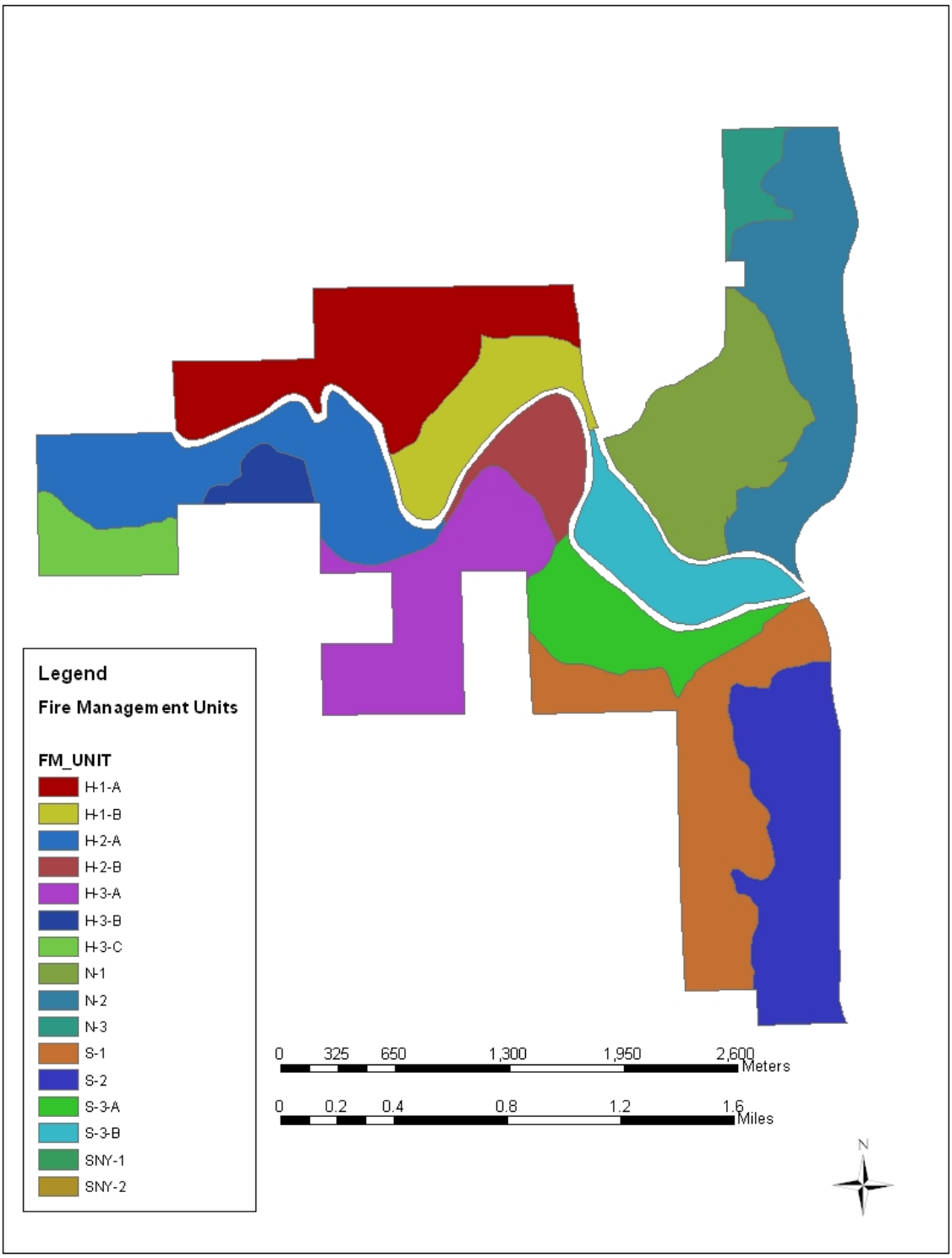

Figure 2 New fire management units at Effigy Mounds National Monument for conducting landscape-scale prescribed fire.

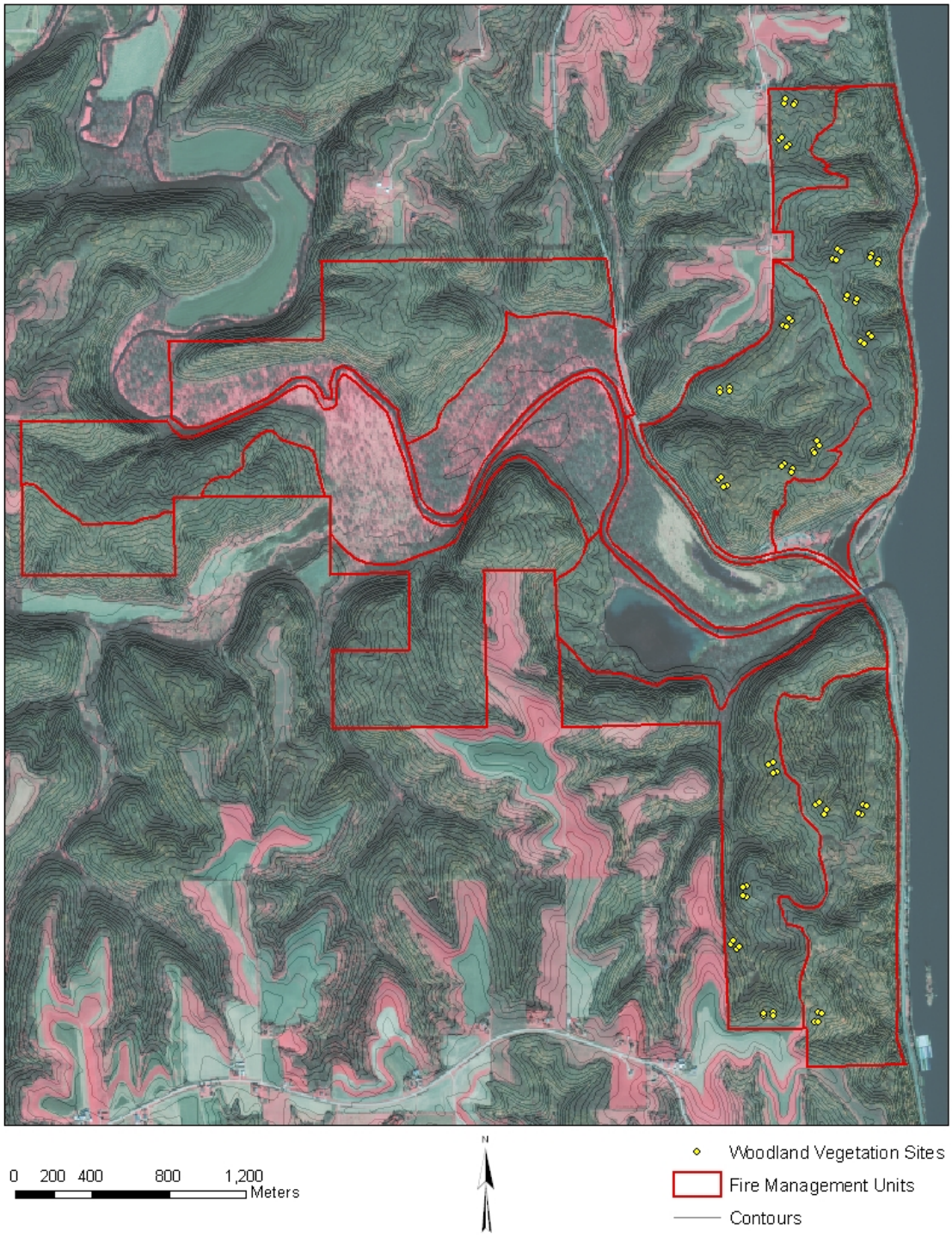

Figure 3 Location of the HTLN long-term vegetation monitoring sites in the woodlands at EFMO.

2. Determine temporal changes in the species composition, structure, and diversity of prairie and woodland communities;
3. Estimate the rate of temporal change for species richness and Shannon diversity, specifically as related to management efforts in restoration of prairie and woodland habitats.
4. Determine the relationship between temporal and spatial changes and environmental variables including specific management practices such as prescribed fire.

3.0 METHODS

3.1 Sample Design

A long-term monitoring program must address the problems associated with sampling numerous parameters through space and time while determining an efficient and effective sampling design. For the HTLN, the primary sample unit consists of two permanent, parallel 50m transects with five sets of nested plots systematically spaced along each transect (Figure 4). The transect pair is the primary sample unit, and is referred to as the sample site. The plot is the secondary sample unit (see DeBacker *et al.* 2005 for additional protocol information).

The plots are used to collect data from the ground flora. Working from the smallest to the largest plot, all herbaceous and woody shrub species are identified. Foliar cover is estimated in the $10m^2$ plot using a modified Daubenmire scale (Table 1). The $10m^2$ plots are also used to collect tree regeneration data. Tree species less than 5.0cm diameter at breast height (dbh) are tallied by species in size classes. For analysis, the site is used as the unit of replication and secondary sample units are pooled or averaged. The 0.1ha area between the two transects is used to collect data on the woody species greater than 5.0cm dbh in the understory and overstory canopy layers.

The variable scale plot design is effective for assessing changes in frequency when sampling multiple species simultaneously. Plot size determines frequency values and frequency values between 30% and 70% allow the greatest potential for detecting increases or declines in species frequency (Elzinga *et al.* 1998). The $0.01m^2$ and $0.1m^2$ plots are useful for detecting changes in frequency of dominant prairie grasses and some ubiquitous forb species. The $1.0m^2$ and $10m^2$ circular plots are useful for detecting changes of satellite or less common grasses and forbs.

3.2 Site Selection

In order to effectively use limited monitoring resources, information derived from a relatively small number of sample sites must be used to infer changes over a much larger area. For the inference to be valid, a probability based sample design within a defined reference frame is required. The many different vegetation types, management practices, and park specific data needs, as well as the logistical constraints related to field work, prohibit comprehensive sampling. This prevents simply treating the park as the study unit. In choosing smaller subsets of the park as study units, park-specific resource management issues and/or the desire to capture landscape and community heterogeneity

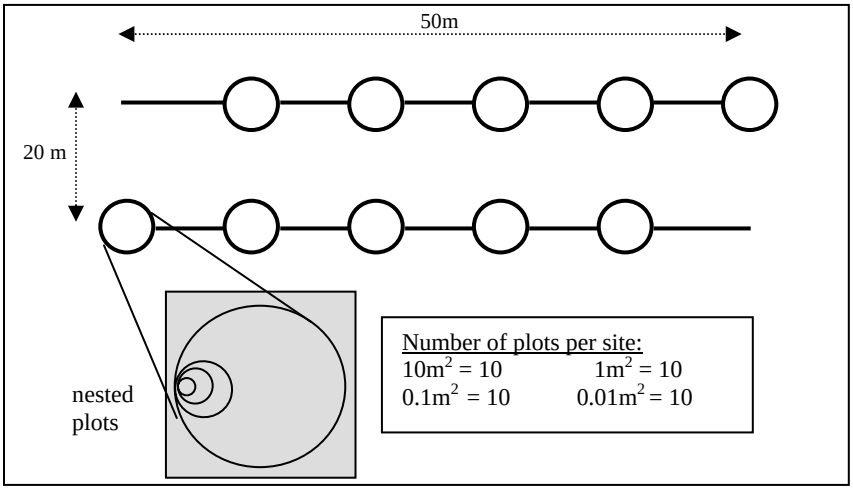

Figure 4 HTLN primary sample unit (i.e., the sample site) comprised of two, 50m long transects with ten sets of nested plots systematically arranged for sampling the ground flora.

Table 1 Modified Daubenmire cover value scale.

Cover Class Codes	Range of Cover (%)
7	95-100
6	75-95
5	50-75
4	25-50
3	5-25
2	1-5
1	0-0.99

guide the selection. The study unit is the reference frame for which statistical inference is made. In general, study units that represent a range of community types (prairie, savanna, woodland, and glade), conditions (high-quality remnants, restored areas), management strategies, and/or harbor rare species are selected.

Effigy Mounds National Monument is divided into a few large, heterogeneous areas generally based on management units. Fire Management Unit N-1 was selected to begin sampling in 2004 as it was the first unit to burn. The N-1 study unit at EFMO contains similar soils, topographic gradients, and vegetation types as other units in the park. In 2005, monitoring was expanding to include all upland forest FMU's in the north and south sections of the park. Again, statistical inference is limited to the study unit, but a weight of evidence approach may be judiciously applied to the park as a whole.

Once a study unit was chosen at EFMO, a stratified, random sample design was used to locate the fire effects monitoring sites. Initially, all areas suitable for sampling were explicitly defined in a GIS as the reference frame. Suitability for sampling included upland forest areas of interest with less than 40% slope. Second, the reference frame was stratified by FMUs, soil type and aspect. Sample sites were then allocated among FMUs and among strata within management units proportionate to their area, ensuring that all areas had an equal probability for inclusion in the sample. Finally, sample sites in each stratum were selected at random from a matrix of potential sites created from a grid overlay of the park (see DeBacker *et al.* 2003 for further information on sample design). A total of 26 sample sites will be required to complete implementation using the same site per area ratio as in unit N-1 (Table 2).

3.3 Data Analysis

The plant community variables and indices selected for data summary purposes are complete and descriptive and were designed to provide resource managers with easily interpretable and timely feedback to assist in assessing management practices (Pickett *et al.* 1992). For analysis, the site, the primary sample unit, is used as the unit of replication and secondary sample units are pooled or averaged. Once estimates for all parameters have been obtained for each sample unit, averages and standard deviation among sample sites can then be obtained for individual study units (management units, reference frames) or for park-wide inference.

From the data collected in each sample site, summary variables are calculated. Summary variables include: (1) plant species richness and diversity, (2) the ratio of exotic to native species, (3) species relative abundance and frequency, (4) plant guild relative abundance, and (5) woody species density and basal area. Changes in these summary variables are used to detect trends over time in the vegetation community.

Table 2 Number of sites per fire management unit based on preliminary sample intensity.

Fire Management Unit	Area (acres)	# of sites per FMU based on site/area ratio from unit N-1	Status
N-1	123.111	5	completed
N-2	109.097	4	completed
N-3	36.36	2	completed
S-1	97.407	4	completed
S-2	79.32	3	completed
S-3-A	111.672	5	not scheduled for implementation
S-3-B	80.443	3	not scheduled for implementation

4.0 RESULTS

For reporting baseline conditions, sample sites were post-stratified by vegetation community type using a vegetation map of the park (www.biology.usgs.gov/npsveg/efmo). One sample site occurs in the Midwestern White oak – Red Oak Forest (white oak – chinquapin oak phase) - FWO, which occupies only a small portion of the burn unit. Four sample sites occur in the Midwestern White Oak - Red Oak Forest (oak hickory phase) - FOH, the dominant community type of the area (Figure 5). The FWO phase is considered the driest of all phases within the Midwestern White Oak – Red Oak Forest community, with an understory community reflecting more woodland and savanna species typically occurring under open canopies. Due to sugar maple and ironwood encroachment, this phase requires active management to retain the woodland-like character. The FOH phase best represents the "typical" Midwestern White Oak – Red Oak Forest plant community. This phase characterizes a forest of mature red oak, white oak and shagbark hickory with less than 25% sugar maple relative dominance and a variety of herbaceous species in the understory.

Pre-burn, 2003

In both community types, the overstory (trees $\geq$ 5cm dbh) comprised eight tree species (Table 3). In the FWO forest type, this layer is dominated by white oak (*Quercus alba*), red oak (*Quercus rubra*) and sugar maple (*Acer saccharum*). Sugar maple shows greater dominance in the FOH forest type, with red oak as a co-dominant. The FWO forest type has more trees per hectare than the FOH forest type, but with smaller trees (as reflected by dbh) (Table 3).

In the regeneration layer, the FWO forest has a greater numbers of seedlings (tree species < 0.5m tall) than the FOH forest type (Table 4). In both community types, sugar maple is the dominant seedling species accounting for 95 to 99% of total regeneration. While dominated by sugar maple, the FOH forest had a greater number of regenerating species than did the FWO forest type. There was very little regeneration for either forest type in either the small or large sapling layers (small saplings ($\geq$ 0.5 m tall & < 2.5 cm dbh) or large saplings ($\geq$ 2.5 cm dbh & < 5.0 cm dbh)).

The herbaceous ground flora layer in the FOH forest sites comprised 50 species (30 families), while the FWO forest type contains 36 ground flora species (21 families). The greater richness in the FOH forest may result from the greater number of sites sampled in that community type. The FOH forest sites are dominated by stinging nettle (*Laportea canadensis*), while the FWO forest site has more heterogeneity in species cover. In general, the two community types have similar species compositions, but in differing proportions. However, these compositional differences may result in variation in response to future prescribed burning.

Post-burn, 2004

In the FOH community, sugar maple regeneration was reduced dramatically after the fire with total seedlings in the four sites declining from 1569 in 2003 to 50 in 2004 (3922.5 per hectare and 125 per hectare, respectively) (Table 5). Sugar maple accounted for 95% of the relative density in 2003 and only 41% in 2004. Black cherry (*Prunus serotina*) and bitternut hickory (*Carya cordiformis*) seedlings were also reduced after the fire, but less dramatically than sugar maple. Significant increases were seen in white ash

(*Fraxinus americana*) and slippery elm (*Ulmus rubra*) regeneration. Honey locust (*Gleditsia triacanthos*) was seen for the first time on the sites after the fire. The small amount of oak regeneration occurring was further reduced after the fire (from four to one stems).

Sugar maple regeneration in the single site in the FWO forest was also greatly reduced from 1642 stems in 2003 to 256 in 2004 (16420/ha and 2560/ha) (Table 6). Though reduced after fire, the number of sugar maple seedlings in the single FWO site is still significantly greater than in the FOH forest sites. Additionally, the number of tree species in the regeneration layer of the FWO site was almost double after the fire (Table 6). In 2003, only five tree species were found, while in 2004 nine species of trees were regenerating. New species include slippery elm, basswood, ironwood, honeylocust, and white ash. No oak regeneration was found either before or after the fire.

Fire has not affected species richness in the FOH forest community with 48 species present in 2004 (50 species in 2003). Exotic species were also not greatly affected, with the only change being the addition of the common dandelion to the sites. Garlic mustard, which occurred prior to the fire, did not change in frequency or foliar cover after the fire. However, foliar cover of stinging nettle was reduced from 39% to 21% cover, but fire had little effect on the frequency of the species. Overall total herbaceous cover was reduced from 49% to 23%. Relative cover of plant guilds did not change after burning, though there was some reduction in spring ephemerals, as would be expected with a spring burn (see Appendix A for full species list and descriptive statistics).

Unlike the FOH forest, plant species richness in the FWO forest site increased following fire, with the addition of 10 new species. Unfortunately, two of the added species were problem exotics, garlic mustard (*Alliaria petiolata*) and multiflora rose (*Rosa multiflora*). An increase was also seen in the relative cover of the summer/fall flowering forb guild, including such species as the elm-leaved goldenrod (*Solidago ulmifolia*) and the wild yam (*Dioscorea villosa*) with 15% cover in 2003 and 28% cover in 2004. Total mean herbaceous cover at the site was not affected, with total cover 5.15% in 2003 and 5% in 2004. May-apple (*Podophyllum peltatum*) was still the most common species after the fire, occurring in 7 out of 10 plots (see Appendix A for full species list and descriptive statistics).

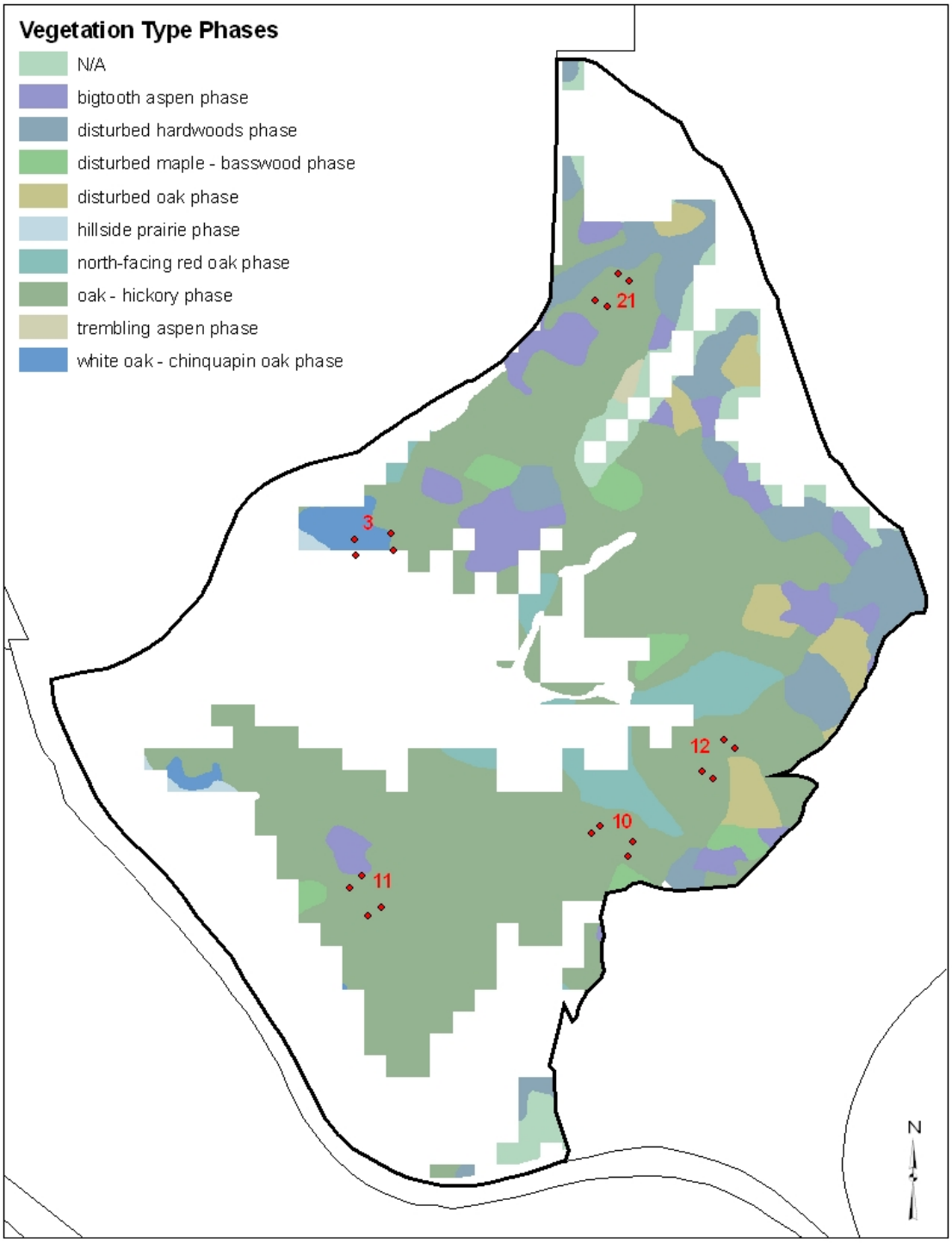

Figure 5 Five sample sites established in fire management unit N-1 in two phases of the Midwestern White Oak – Red Oak Forest community.

Table 3 Results of overstory sampling in 2003 at Effigy Mounds National Monument.

Scientific Name	Common Name	Relative Basal Area (%)		Relative Density (%)		Importance Value	
		FWO Forest	FOH Forest	FWO Forest	FOH Forest	FWO Forest	FOH Forest
Acer saccharum	sugar maple	18.36	32.10	30.99	48.63	0.25	0.40
dead *Acer saccharum*	dead sugar maple	0.04	0.64	1.41	1.09	0.00	0.01
Carya cordiformis	bitternut hickory	0	0.53	0	1.64	0.00	0.01
Carya ovata	shagbark hickory	0.55	0	1.41	0	0.00	0
Carya spp.	hickory spp.	1.43	0	1.41	0	0.01	0
Fraxinus pennsylvanica	green ash	0	10.79	0	4.92	0.05	0.08
Ostrya virginiana	ironwood	0.61	0.34	12.68	4.92	0.00	0.03
dead *Ostrya virginiana*	dead ironwood	0.23	0	5.63	0	0.00	0
Prunus serotina	black cherry	0.75	0	1.41	0	0.00	0
Quercus alba	white oak	47.16	1.99	22.54	1.64	0.25	0.02
dead *Quercus alba*	dead white oak	3.34	0	1.41	0	0.02	0
Quercus rubra	N. red oak	19.73	42.09	9.86	18.58	0.31	0.30
dead *Quercus rubra*	dead N. red oak	0	1.69	0	0.55	0.01	0.01
Snag	unknown dead tree	2.50	0.33	5.63	0.55	0.01	0.00
Tilia americana	basswood	5.29	8.89	5.63	6.56	0.07	0.08
dead *Tilia americana*	dead basswood	0	0.06	0	0.55	0.00	0.00
Ulmus rubra	slippery elm	0	0.53	0	10.38	0.00	0.05

Table 4 2003 tree species regeneration for both forest community types in FMU N-1.

Scientific Name	Common Name	FWO Forest		FOH Forest	
		Density	Relative Density (%)	Density	Relative Density (%)
Acer saccharum	sugar maple	1642	99.27	1569	95.09
Carya cordiformis	bitternut hickory	1	0.06	31	1.88
Carya spp	hickory species	1	0	0	0
Celtis occidentalis	hackberry	1	0.06	0	0
Fraxinus americana	white ash	0	0	22	1.33
Gleditsia triacanthos	honey locust	0	0	0	0
Ostrya virginiana	ironwood	0	0	2	0
Prunus serotina	black cherry	9	0.54	17	0.12
Quercus alba	white oak	0	0	2	0.12
Quercus rubra	red oak	0	0	2	0.12
Tilia americana	basswood	0	0	0	0
Ulmus rubra	slippery elm	0	0	5	0.3
	Total	**1654**		**1650**	

Table 5 FOH forest community (4 sites) tree species regeneration before and after prescribed fire.

Scientific Name	Common Name	Density		Relative Density	
		2003	2004	2003	2004
Acer saccharum	sugar maple	**1569**	**50**	**95.09**	**41.32**
Carya cordiformis	bitternut hickory	31	18	1.88	14.88
Carya spp	hickory species	0	4	0	3.31
Fraxinus americana	white ash	22	30	1.33	24.79
Gleditsia triacanthos	honey locust	0	1	0	0.83
Ostrya virginiana	ironwood	2	0	0	0
Prunus serotina	black cherry	17	0	0.12	0
Quercus alba	white oak	2	0	0.12	0
Quercus rubra	red oak	2	1	0.12	0.83
Tilia americana	basswood	0	2	0	1.65
Ulmus rubra	slippery elm	5	15	0.3	12.4
	TOTAL	**1650**	**121**		

Table 6 FWO forest community (1 site) tree species regeneration before and after prescribed fire.

Scientific Name	Common Name	Density		Relative Density	
		2003	2004	2003	2004
Acer saccharum	sugar maple	**1642**	**256**	99.27	87.97
Carya cordiformis	bitternut hickory	1	1	0.06	0.34
Carya spp	hickory species	1	1	0	0.34
Celtis occidentalis	hackberry	1	0	0.06	0.00
Fraxinus americana	white ash	0	5	0	1.72
Gleditsia triacanthos	honey locust	0	1	0	0.34
Ostrya virginiana	ironwood	0	19	0	6.53
Prunus serotina	black cherry	9	2	0.54	0.69
Tilia americana	basswood	0	2	0	0.69
Ulmus rubra	slippery elm	0	4	0	1.37
	TOTAL	**1654**	**291**		

5.0 DISCUSSION

Natural resource managers at Effigy Mounds National Monument (EFMO) are concerned that forest succession is resulting in a loss of forest diversity and degradation of park mandated viewscapes. Regeneration and overstory data suggest a transition is occurring from a drier, oak/hickory forest to one dominated by more mesic species, particularly sugar maple. Grabner *et al.* (2000) similarly described the current state of the monuments forest as overgrown savanna. Using tree core analysis, they determined that the invasion of sugar maple, basswood and additional mesic species has occurred within the last 40 years. This succession favors climax forests, at the loss of prairie and savanna communities, as nearly 1,200 acres of the monument are rapidly becoming mature stands of mixed hardwood species.

With the enlargement of the prescribed fire program into the woodland portions of the park, it is important to understand the effects of the initial 2004 burn. One positive result of the burn was the reduction in sugar maple seedlings. With additional burns, reductions in sugar maples may be seen in the larger sapling and tree layers, also. As would be expected, one spring fire has not greatly affected the ground flora composition of either forest communities. The largest change occurred in the dominant species, stinging nettle, in the FOH forest with a 50% reduction in cover. This may be a temporary effect, however, as there was not a subsequent increase in other plant species. The only negative response seen in 2004 was the addition of both garlic mustard and multiflora rose to the FWO forest site. However, with only one sample site in this forest community the effect cannot be directly attributed to the prescribed fire.

The data from the additional FMU's collected in the next few years will add to the knowledge gained from the FMU burned in 2004 and allow for greater interpretation of the results. In order for scientifically sound management decisions to be made, current information on plant species composition, structure and woody fuels are needed. The additional baseline monitoring in the EFMO woodlands will help park staff to predict the possible impacts of management decisions on forested ecosystems.

6.0 LITERATURE CITED

DeBacker, M.D., A.N. Sasseen, C. Becker, G.A. Rowell, L.P. Thomas, J.R. Boetsch and G.D. Willson. 2004. Vegetation Community Monitoring Protocol for the Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program. National Park Service, The Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program, Wilson's Creek National Battlefield, Republic, Missouri.

DeBacker, M., J. DeCoster, J. Haack, K. Hansen and A. Sasseen. 2003. Sample design and summary of baseline conditions for fire effects monitoring in deciduous forest at Effigy Mounds National Monument. National Park Service, The Heartland I&M Network and Prairie Cluster Prototype Monitoring Program.

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. Measuring and Monitoring Plant Populations. BLM Technical Reference 1730 – 1. Denver, Colorado.

Grabner, K.W., S.E. Jenkins and M. DeBacker. 2000. Goat Prairie 14 (Burr Oak Savanna) and Marching Bear Mounds Management Recommendations. Unpublished report to the National Park Service, USGS Missouri Field Station, Northern Prairie Science Center.

National Park Serice. 2003. Fire Management Plant for Effigy Mounds National Monument.

Appendix A: Summary Statistics for the 2004 Sample Event for the Midwestern White Oak –Red Oak Forest in both the oak – hickory phase and the white oak – chinquapin phase.

Midwestern White Oak – Red Oak Forest (oak – hickory phase)

Table 1a. Plant Community Composition: Species Richness and Shannon Diversity.

All Species:

Species Richness:	**48**			
Total Shannon Diversity:	**1.20**	Total Shannon Evenness:	**0.31**	
Mean Diversity (st dev):	**1.53 (1.11)**	Mean Evenness (st dev):	**0.46**	**(0.32)**

Native Species Only:

Native Species Richness:	**43**			
Total Shannon Diversity:	**1.10**	Total Shannon Evenness:	**0.29**	
Mean Diversity (st dev):	**1.45 (1.12)**	Mean Eveness (st dev):	**0.44**	**(0.32)**

Table 1b. Plant Community Summary: Relative Frequency and Cover of Exotic Species.

Number of Exotic Species: **2**
Number of Native Species: **43**
Exotic Ratio: **0.044**

	Mean Relative Frequency	Mean Relative Cover
I	**1.68%**	**0.45%**
N	**98.32%**	**99.55%**

Table 1c. Plant Community Composition: Relative Frequency and Cover of Plant Guilds.

Plant Guild	Mean Relative Cover (st dev)	Mean Relative Frequency (st dev)
Annuals and Biennials	**2.45% (0.024)**	**8.64% (0.020)**
Cool-Season Grasses	**0.36% (0.007)**	**0.69% (0.000)**
Ephemeral Spring Forbs	**1.35% (0.016)**	**4.76% (0.038)**
Ferns	**7.24% (0.067)**	**11.36% (0.021)**
Grass-Like	**0.28% (0.002)**	**1.90% (0.009)**
Legumes	**1.61% (0.008)**	**4.07% (0.036)**
Spring Forbs	**9.38% (0.117)**	**27.09% (0.049)**
Summer/Fall Forbs	**72.79% (0.247)**	**29.46% (0.013)**
Woody Species	**4.49% (0.052)**	**11.75% (0.017)**

Table 2a. Plant Community Structure: Ground Cover.

Structural Component	Mean Percent Cover
BARE SOIL	**30.03**
BARE ROCK	**0.01**
WOODY DEBRIS	**16.20**
LEAF LITTER	**47.84**
UNVEGETATED SURFACE	**87.63**

Table 2b. Plant Community Structure: Vegetation Type Cover.

Vegetation Type	Mean Percent Cover
Ferns and Fern Allies	**1.16**
Grasses/Grass-Like	**0.10**
Herbs	**20.94**
Shrubs	**0.01**
Woody Vines	**0.49**

Table 3a. Plant Community Composition: Herbaceous and Shrub Species.

Species	**Common Name**	**Frequency**	**Mean Cover**	**Importance Value**
LAPORTEA CANADENSIS	Stinging Nettle	85.00%	21.00	0.3706
PARTHENOCISSUS QUINQUEFOLIA	Virginia-creeper, woodbine	77.50%	0.58	0.0662
ATHYRIUM FILIX-FEMINA	Common ladyfern	52.50%	1.55	0.0560
CIRCAEA LUTETIANA SSP. CANADENSIS	Common enchanter's nightshade	55.00%	0.61	0.0471
PILEA PUMILA	Clearweed	55.00%	0.50	0.0442
VIOLA SORORIA	Violet	42.50%	0.50	0.0334
UVULARIA GRANDIFLORA	Bellwort, merrybells	37.50%	0.50	0.0321
SANICULA SPP.	Sanicula trifida and S.	37.50%	0.50	0.0321
ADIANTUM PEDATUM	Northern maidenhair	27.50%	1.18	0.0268
OSMORHIZA CLAYTONII	Clayton's sweetroot	30.00%	0.50	0.0259
ARISAEMA TRIPHYLLUM	Jack-in-the-pulpit	27.50%	0.50	0.0250
SANGUINARIA CANADENSIS	Bloodroot	32.50%	0.50	0.0219
CRYPTOTAENIA CANADENSIS	Canadian Honewort	17.50%	0.86	0.0206
PHRYMA LEPTOSTACHYA	Lopseed	22.50%	0.50	0.0182
PODOPHYLLUM PELTATUM	May-apple, mandrake	17.50%	0.50	0.0156
AMPHICARPA BRACTEATA	Hog-peanut	17.50%	1.21	0.0153
CAULOPHYLLUM THALICTROIDES	Blue cohosh	15.00%	0.50	0.0138
VIOLA SPP	Violet	15.00%	0.50	0.0126
DESMODIUM GLUTINOSUM	Cluster-leaf tick-trefoil	15.00%	0.92	0.0115
ASARUM CANADENSE	Wild ginger	7.50%	0.50	0.0093
CAREX PLANTAGINEA	Sedge	12.50%	0.50	0.0084
TARAXACUM OFFICINALE	Common dandelion	10.00%	0.50	0.0072
VITIS SPP	Grape	7.50%	0.50	0.0067
ANEMONE VIRGINIANA	Tall anemone, thimbleweed	7.50%	0.50	0.0065
HYDRASTIS CANADENSIS	Goldenseal	5.00%	0.50	0.0062
IMPATIENS SPP	Touch-me-not	5.00%	1.75	0.0051
FESTUCA SUBVERTICILLATA	Nodding fescue	5.00%	0.50	0.0049
ARALIA RACEMOSA	Spikenard	5.00%	0.50	0.0049
GALIUM APARINE	Cleavers	7.50%	0.50	0.0047
BOTRYCHIUM VIRGINIANUM	Rattlesnake-fern	5.00%	0.50	0.0047
SMILAX ECCIRATA	upright carrionflower	5.00%	0.50	0.0047
GEUM CANADENSE	White avens	5.00%	0.50	0.0034
ASTER LATERIFLORUS	Goblet wild aster	2.50%	0.50	0.0031
HACKELIA VIRGINIANA	Stickseed, beggar's lice	2.50%	0.50	0.0031
RIBES MISSOURIENSE	Missouri gooseberry	2.50%	0.50	0.0031
CIMICIFUGA RACEMOSA	Black bugbane	2.50%	0.50	0.0031
PHLOX DIVARICATA	Forest phlox	2.50%	0.50	0.0031
ALLIARIA PETIOLATA	Garlic-mustard	2.50%	3.00	0.0028
URTICA DIOICA SSP. GRACILIS	Nettle, stinging nettle	2.50%	0.50	0.0019
PHYSALIS SPP		2.50%	0.50	0.0018

Species	Common Name	Frequency	Mean Cover	Importance Value
CIRSIUM SPP	Thistle	2.50%	0.50	0.0018
CAREX SPP	Sedge	2.50%	0.50	0.0018
POLYGONUM VIRGINIANUM	Jumpseed	2.50%	0.50	0.0016
ASTER SPP	Aster species	2.50%	0.50	0.0016
SOLIDAGO RIGIDA	Stiff goldenrod	2.50%	0.50	0.0016
MAIANTHEMUM RACEMOSUM SSP. RACEMOSUM	False/Wild lily-of-the-valley	2.50%	0.50	0.0016
VIOLA PUBESCENS	Downy yellow violet	2.50%	0.50	0.0016
VIOLA STRIATA	Striped cream violet	2.50%	0.50	0.0016

Table 3b. Plant Community Composition: Exotic Species.

Species	Common Name	Frequency	Mean Cover	Importance Value
TARAXACUM OFFICINALE	Common dandelion	10.00%	0.50%	0.0072
ALLIARIA PETIOLATA	Garlic-mustard	2.50%	3.00%	0.0028

Midwestern White Oak – Red Oak Forest (white oak – chinquapin oak phase)

Table 1a. Plant Community Composition: Species Richness and Shannon Diversity.

All Species:

Species Richness:	**46**		
Total Shannon Diversity:	**3.58**	Total Shannon Evenness:	**0.93**
Mean Diversity (st dev):	**3.58**	Mean Evenness (st dev):	**0.93**

Native Species Only:

Native Species Richness:	**41**		
Total Shannon Diversity:	**3.48**	Total Shannon Evenness:	**0.94**
Mean Diversity (st dev):	**3.48**	Mean Eveness (st dev):	**0.94**

Table 1b. Plant Community Summary: Relative Frequency and Cover of Exotic Species.

Number of Exotic Species: **3**
Number of Native Species: **41**
Exotic Ratio: **0.068**

	Mean Relative Frequency	Mean Relative Cover
I	**8.42%**	**8.42%**
N	**91.58%**	**91.58%**

Table 1c. Plant Community Composition: Relative Frequency and Cover of Plant Guilds.

Plant Guild	Mean Relative Cover (st dev)	Mean Relative Frequency (st dev)
Annuals and Biennials	**6.90%**	**6.90%**
Cool-Season Grasses	**11.49%**	**11.49%**
Ephemeral Spring Forbs	**17.24%**	**17.24%**
Ferns	**5.75%**	**5.75%**
Grass-Like	**6.90%**	**6.90%**
Legumes	**6.90%**	**6.90%**
Spring Forbs	**10.34%**	**10.34%**
Summer/Fall Forbs	**27.59%**	**27.59%**
Warm-Season Grasses	**1.15%**	**1.15%**
Woody Species	**4.60%**	**4.60%**

Table 2a. Plant Community Structure: Ground Cover.

Structural Component	Mean Percent Cover
BARE SOIL	**23.85**
BARE ROCK	**0.30**
GRASS LITTER	**4.25**
WOODY DEBRIS	**14.60**
LEAF LITTER	**39.00**
UNVEGETATED SURFACE	**96.25**

Table 2b. Plant Community Structure: Vegetation Type Cover.

Vegetation Type	Mean Percent Cover
Ferns and Fern Allies	**0.25**
Grasses/Grass-Like	**0.85**
Herbs	**3.65**
Shrubs	**0.15**
Woody Vines	**0.10**

Table 3a. Plant Community Composition: Herbaceous and Shrub Species.

Species	**Common Name**	**Frequency**	**Mean Cover**	**Importance Value**
PODOPHYLLUM PELTATUM	May-apple, mandrake	70.00%	0.50	0.0693
VIOLA SPP	Violet	60.00%	0.50	0.0594
BRACHYELYTRUM ERECTUM	Grass	60.00%	0.50	0.0594
TARAXACUM OFFICINALE	Common dandelion	60.00%	0.50	0.0594
DIOSCOREA VILLOSA	Colic-root	50.00%	0.50	0.0495
OSMORHIZA CLAYTONII	Clayton's sweetroot	50.00%	0.50	0.0495
SANICULA SPP.	Blacksnakeroot	50.00%	0.50	0.0495
BOTRYCHIUM VIRGINIANUM	Rattlesnake-fern	40.00%	0.50	0.0396
CAREX SPP	Sedge	40.00%	0.50	0.0396
ANEMONE VIRGINIANA	Tall anemone, thimbleweed	30.00%	0.50	0.0297
FESTUCA SUBVERTICILLATA	Nodding fescue	30.00%	0.50	0.0297
SOLIDAGO ULMIFOLIA	Elm-leaved goldenrod	30.00%	0.50	0.0297
ASTER SPP.	Aster species	20.00%	0.50	0.0198
CIRCAEA LUTETIANA SSP. CANADENSIS	Common enchanter's nightshade	20.00%	0.50	0.0198
AMPHICARPA BRACTEATA	Hog-peanut	20.00%	0.50	0.0198
PHRYMA LEPTOSTACHYA	Lopseed	20.00%	0.50	0.0198
PARIETARIA PENSYLVANICA	Pennsylvania pellitory	20.00%	0.50	0.0198
DESMODIUM NUDIFLORUM	Naked tick-trefoil	20.00%	0.50	0.0198

Species	Common Name	Frequency	Mean Cover	Importance Value
ASTER LATERIFLORUS	Goblet wild aster	20.00%	0.50	0.0198
CHENOPODIUM ALBUM	Lamb's quarters, pigweed	20.00%	0.50	0.0198
CAREX PLANTAGINEA	Sedge	20.00%	0.50	0.0198
THALICTRUM THALICTROIDES	Meadow-rue	20.00%	0.50	0.0198
CHASMANTHIUM LATIFOLIUM	Indian woodoats	10.00%	0.50	0.0099
CIMICIFUGA RACEMOSA	Black bugbane	10.00%	0.50	0.0099
BIDENS SPP	Beggarticks	10.00%	0.50	0.0099
DESMODIUM GLUTINOSUM	Cluster-leaf tick-trefoil	10.00%	0.50	0.0099
ARABIS SPP	Rockcress	10.00%	0.50	0.0099
VITIS SPP	Grape	10.00%	0.50	0.0099
ALLIARIA PETIOLATA	Garlic-mustard	10.00%	0.50	0.0099
UVULARIA GRANDIFLORA	Bellwort, merrybells	10.00%	0.50	0.0099
GALIUM CONCINNUM	Bedstraw, cleavers	10.00%	0.50	0.0099
ROSA MULTIFLORA	Multiflora rose	10.00%	0.50	0.0099
PILEA PUMILA	Clearweed	10.00%	0.50	0.0099
PARTHENOCISSUS QUINQUEFOLIA	Virginia-creeper, woodbine	10.00%	0.50	0.0099
SMILAX ECCIRATA	Upright carrionflower	10.00%	0.50	0.0099
MUHLENBERGIA TENUIFLORA	Muhly	10.00%	0.50	0.0099
CONYZA CANADENSIS	Horseweed	10.00%	0.50	0.0099
GALIUM SPP	Cleavers	10.00%	0.50	0.0099
ERECHTITES HIERACIIFOLIA	Fireweed	10.00%	0.50	0.0099
ZANTHOXYLUM AMERICANUM	Common prickly ash	10.00%	0.50	0.0099
SOLIDAGO BUCKLEYI	Buckley's goldenrod	10.00%	0.50	0.0099
ADIANTUM PEDATUM	Northern maidenhair	10.00%	0.50	0.0099
DESMODIUM SPP	Tick Tre-foil	10.00%	0.50	0.0099
RIBES MISSOURIENSE	Missouri gooseberry	10.00%	0.50	0.0099
CRYPTOTAENIA CANADENSIS	Canadian Honewort	10.00%	0.50	0.0099
GEUM CANADENSE	White avens	10.00%	0.50	0.0099

Table 3b. Plant Community Composition: Exotic Species.

Species	Common Name	Frequency	Mean Cover	Importance Value
TARAXACUM OFFICINALE	Common dandelion	60.00%	0.50%	0.0594
ROSA MULTIFLORA	Multiflora rose	10.00%	0.50%	0.0099
ALLIARIA PETIOLATA	Garlic-mustard	10.00%	0.50%	0.0099